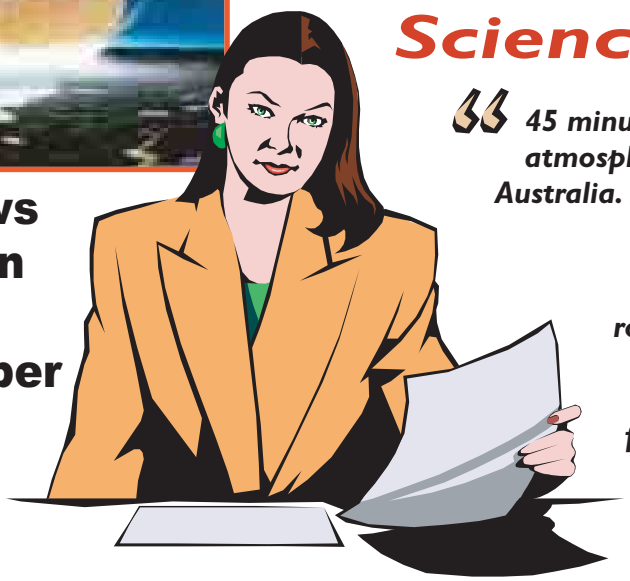
Crater Impact

Science fact or fiction

TV News Bulletin 10:58 September 2004



"45 minutes ago, a huge space rock swept into our atmosphere and punched out a massive crater in Australia. Everyone and everything within 150 km was instantly vaporised.

The impact hurled hundreds of tonnes of rock and sand into the atmosphere. Terrified people around the world are watching as meteors and brilliant fireballs rain down from a pink sky. Fires are reducing parts of the UK to ashes."

Your investigation

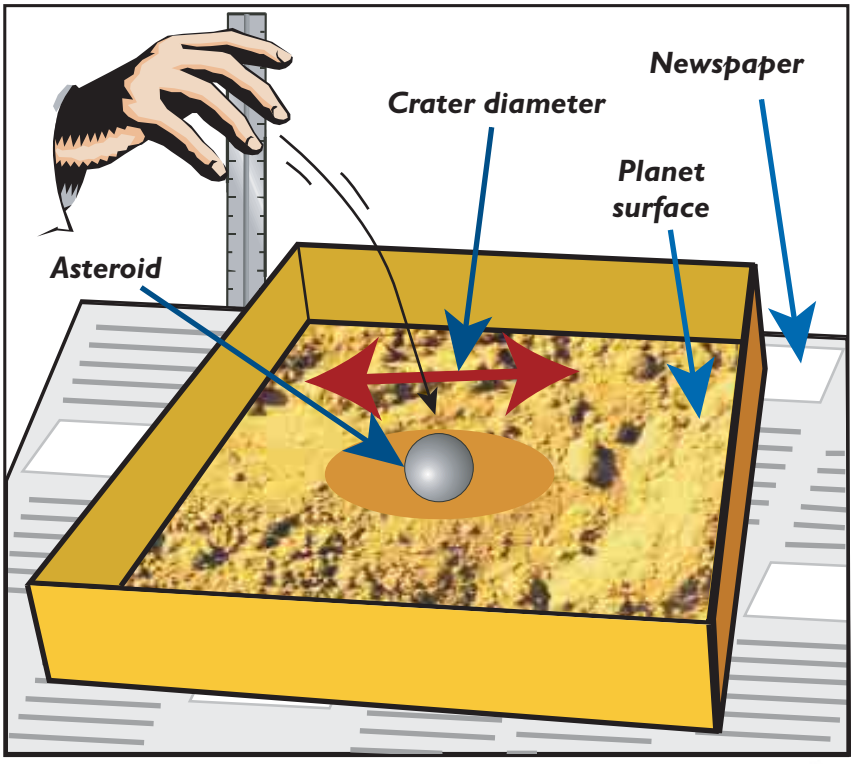
Could this really happen? There are over 1 million known asteroids. Most are very small, but space rocks a kilometre in size do pass close to Earth. One hits us roughly every 100,000 years. The next one could hit us any time soon.

Your investigation is to find out how big the effects of an asteroid impact could be. You can estimate how far the debris from the impact might travel, or how big the impact crater could be. To do this you will study impacts made by dropping small objects into sand. The equipment you need is shown in the diagram below.

Try dropping your 'asteroid' and observe what happens. What does the impact crater look like? Did you notice the debris thrown out from the impact?

Questions to investigate

Preparing the planet: ***The 'planet surface' is sand. Fill your container to a depth of at least 3cm. Smooth the surface so the sand is even. Dropping the 'asteroid' gives it speed when it hits the 'planet'. Debris range is the furthest distance debris travels from the asteroid.***



Choose one of these:

1 How does the **speed** of the asteroid affect:
   a) the debris range?
   b) the crater size?

2 How does the **mass** of the asteroid affect:
   a) the debris range?
   b) the crater size?

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Help Sheet

Planning

Think about:

- Doing a trial run to see how well your experiment works.
- How you will vary the speed or mass of the asteroid.
- What variables you need to keep the same to make it a fair test.
- Making a prediction, from what you know about energy (and the information below).
- Explain your prediction. Use what you have learnt about kinetic energy.

Useful information about energy:

- The more kinetic energy the object has:
  a) the bigger the crater is, and
  b) the further the debris travels.
- The kinetic energy the object has on impact = the (gravitational) potential energy it started with when you dropped it.

Making observations

Think about:

- What range of measurements you will need to make to give reliable results.
- How you will measure speed, mass and distance accurately.
- How you can reduce the errors in your experiment.
- How many times you need to repeat your measurements so your results are more accurate.

Useful information about speed and height:

- The impact speed of the asteroid is related to the height you drop it from.
- It is much easier to measure the drop height than the impact speed.
- You can use the table below to convert your drop heights to impact speed.
- Or, you can use the formula:

speed, $v = \sqrt{}$ (20 x height),

where the height is in metres.

Drop Height (m)	Impact Speed (m/s)
0.2	2.0
0.4	2.83
0.6	3.46
0.8	4.00
1.0	4.47
1.2	4.90
1.4	5.29
1.6	5.66

Considering evidence

Think about:

- How you will present your results: in a table, chart or graph?
- How you will draw a conclusion from your results.
- Your conclusion must be based on your results.
- Whether your conclusion agrees with the prediction you made.

Evaluation

Think about:

- Are the repeats of your results close enough together to show that they are reliable?
- How could you improve either the method you used or the accuracy of your measurements?

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Extension Activity 1

How far would debris from a real impact in Australia travel?

a Write down, or estimate, the debris range, in metres, for an 'asteroid' of 2cm diameter, dropped from a height of 0.8m (impact speed= 4m/s).

b A real asteroid could be:
1km diameter....(50,000 x bigger)
Travelling at 4 km/s....(1000 x faster)

Assume debris range is proportional to asteroid diameter and speed. We can then say:

Debris range (real asteroid) = debris range (your asteroid) x 50,000,000

Calculate, using the formula, the debris range of a real asteroid
i) in metres (m)
and
ii) in kilometres (km).

c Write down parts of the world or countries that are within the debris range, using the map below.

d List some assumptions made in this estimate.
Do you think they are realistic or not?

Extension Activity 2

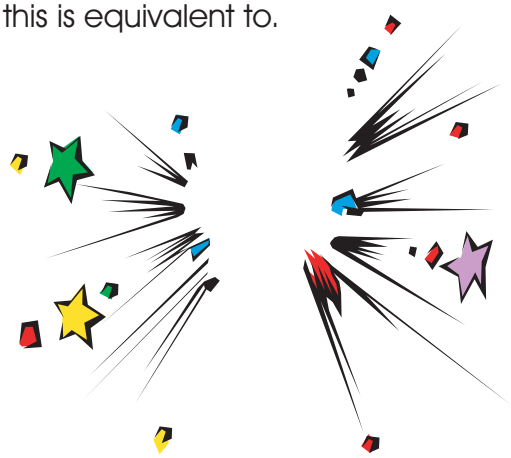
How much energy would be released in the explosion?

a Calculate the volume of a 500m radius asteroid using the formula:
Volume = 4/3 x π x (radius)^3,
where π = 3.14

b Calculate the mass of the asteroid using the formula:
Mass = volume x density (assume it is rock, with density = 5500 kg/m^3)

c Calculate the kinetic energy of the asteroid (assume the speed is 4,000m/s)

d Estimate how many nuclear bombs this is equivalent to.



(1 large nuclear bomb produces 2.4 X 10^{17} Joules)

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Extension Activity 3

How likely are we to suffer an asteroid impact?

Asteroid diameter (km)	Estimated no. near earth	Impact Probability (in 1 year)		Would it cause global catastrophe?
0.001 (1m)	10,000,000	0.01	(1 every 100 years)	No
0.1 (100m)	100,000	0.0001	(1 every 10,000 years)	No
1	1,000	0.00001	(1 every 100,000 years)	Yes
10	10	0.000001	(1 every million years)	Yes

a Which size objects are:
- i) Most likely to hit us
- ii) Least likely to hit us

b Which are most common, big or small asteroids?

Cause of death	Probability
Fire	0.0012
Plane crash	0.00005
Flood	0.00003
Fireworks accident	0.000001
Food poisoning	0.0000003

c How many objects could cause a global catastrophe?

d What is the probability of an impact causing global catastrophe in any year?

e Calculate the probability of dying from a meteorite impact using the formula:

Probability (in any year) = *Probability of an impact causing global catastrophe* x *¼ (the probability of being killed by it)*

f Which two other causes of death shown in the table is this probability closest to?

g Is your answer to (f) surprising? Describe why.

Extension Activity 4

Should we protect ourselves from meteor impact?

A new project called 'Spaceguard' could help us detect asteroids near the Earth.

It involves building a ring of telescopes around the world. The cost of the project for the UK would be £1 million a year for 10 years.

a List reasons why it is important to detect asteroids.

b Imagine you are trying to persuade the Minister of Science to fund this project. Write a letter giving your arguments.

c The Minister is impressed with your letter. She invites you to help develop ways to stop an asteroid heading for collision with Earth. She mentions films like Deep Impact and Armageddon, which suggest we could use a nuclear bomb. Describe how a nuclear bomb could be used to stop the asteroid colliding with earth. Include a diagram to show how your idea works.

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